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## “EXTRAORDINARY” AND “HIGHLY CONTROVERSIAL”: FEDERAL RESEARCH OF SOLAR GEOENGINEERING UNDER NEPA

*Charles R. Corbett*

**ABSTRACT**—Congress recently instructed the National Oceanic and Atmospheric Administration (NOAA) to investigate stratospheric aerosols, materials that could be injected in the atmosphere as a means of solar climate intervention. This action has been widely interpreted as the first-ever federal research project into solar geoengineering—proposals to slightly “dim the sun” to limit the harms of climate change. This Essay argues that NOAA should use its discretion to conduct a programmatic environmental assessment under the National Environmental Policy Act (NEPA) as an initial step in governing this research program. Federal research into solar geoengineering is an extraordinary and highly controversial policy. The agency should carefully consider the environmental, social, and political impacts that may come with this undertaking. Further, the public deserves an opportunity to weigh in on the matter and to be apprised of its potential benefits and risks. NEPA provides a rigorous framework for doing just that.

**AUTHOR**—Emmett Climate Engineering Fellow in Environmental Law and Policy, Emmett Institute, UCLA School of Law 2019–2021. My thanks to Holly Buck, Leilani Doktor, Sean Hecht, Ted Parson, Jesse Reynolds, Shuchi Talati, and Daniele Visioni for their comments and assistance. This Essay builds on an analysis published in a blog post on *Legal Planet* in February 2020.

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## INTRODUCTION

Solar geoengineering, first proposed nearly fifty years ago<sup>1</sup> and seriously investigated by a small scientific community since the mid-2000s, has largely been sidelined from mainstream climate policy.<sup>2</sup> The idea is outlandish: Solar geoengineers would limit the ravages of global warming by making the atmosphere more reflective, which would limit the amount of solar energy that enters our planet's climate system and thus cool the planet off.<sup>3</sup> Solar geoengineering could possibly be regional, with fleets of ships seeding bright, shiny cloud cover over parts of the ocean, cooling the air and waters below.<sup>4</sup> Or it could be global, depositing reflective fine particles or gases high in the upper atmosphere, which would cool the entire planet for a time, much as some large volcanic eruptions have.<sup>5</sup> Climate modeling has shown that these ideas, as strange as they seem, could work. Planetary-scale solar geoengineering would likely generate a rapid and substantial cooling effect at modest direct costs.<sup>6</sup>

But solar geoengineering alone would be a clumsy and imperfect response to climate change. It would not remove climate pollution from the

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<sup>1</sup> See D. N. Bernstein, J. D. Neelin, Q. B. Li & D. Chen, *Could Aerosol Emissions Be Used for Regional Heat Wave Mitigation?*, 13 *ATMOSPHERIC CHEMISTRY & PHYSICS* 6373, 6373 (2013) (citing MIKHAIL IVANOVICH BUDYKO, *CLIMATE AND LIFE* (1974)).

<sup>2</sup> See Peter C. Frumhoff & Jennie C. Stephens, *Towards Legitimacy of the Solar Geoengineering Research Enterprise*, 376 *PHIL. TRANSACTIONS ROYAL SOC'Y A*, Apr. 2, 2018, at 2–3.

<sup>3</sup> See INT'L PANEL ON CLIMATE CHANGE, *GLOBAL WARMING OF 1.5°C* 349–52 (2018) [hereinafter IPCC]. Solar geoengineering also includes proposals to thin cirrus clouds to allow greater escape of energy back into space, but reflectivity-enhancing interventions are better understood and more often discussed by researchers. See *id.* at 348 tbl.4.7.

<sup>4</sup> See *id.* (describing marine cloud brightening).

<sup>5</sup> See *id.* (describing stratospheric aerosol injection).

<sup>6</sup> See *id.* at 348–49.

atmosphere, but merely mask its effects on temperature.<sup>7</sup> Other climate harms, like ocean acidification, would therefore remain the same or worsen during deployment.<sup>8</sup> It would also be temporary, lasting only a few years, and so it would need to be reapplied regularly to maintain its cooling effect.<sup>9</sup> Furthermore, it is unclear how global deployment would reverberate through natural systems, or how regional interventions could disturb weather and climate in other parts of the planet.<sup>10</sup> This is why solar geoengineering could, at best, only complement efforts to zero out greenhouse gas emissions (“mitigation”). It can be no substitute.

There are also serious concerns over political control.<sup>11</sup> Who will run these research programs? Who will hold them accountable? Who will decide what the climate will be? And how will these decisions interact with other parts of climate policy? Some observers have concluded that it would be impossible to resolve these questions fairly, or that the uncertainties inherent in solar geoengineering are too great to allow research to go forward.<sup>12</sup> Even research advocates largely agree that deploying these technologies would be far from ideal; it would be better to avoid research altogether and pursue mitigation and adaptation alone.<sup>13</sup>

Or, perhaps, it *would have been* better: despite decades of warnings, mainstream climate policy has largely failed to “bend the curve” on global greenhouse gas emissions.<sup>14</sup> It increasingly looks as though mitigation and adaptation efforts alone will be insufficient to avert severe and irreversible harm to the planet.<sup>15</sup> Meanwhile, the effects of climate change have already begun to appear, and they are expected to worsen at an accelerating pace.<sup>16</sup>

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<sup>7</sup> See JESSE L. REYNOLDS, THE GOVERNANCE OF SOLAR GEOENGINEERING: MANAGING CLIMATE CHANGE IN THE ANTHROPOCENE 24–27 (2019).

<sup>8</sup> *Id.*

<sup>9</sup> ROYAL SOC’Y, GEOENGINEERING THE CLIMATE: SCIENCE, GOVERNANCE AND UNCERTAINTY 29 (2009).

<sup>10</sup> REYNOLDS, *supra* note 7, at 24–27.

<sup>11</sup> *Id.* at 28–30.

<sup>12</sup> See, e.g., NAOMI KLEIN, THIS CHANGES EVERYTHING: CAPITALISM VS. THE CLIMATE 266–67, 277–78 (2014).

<sup>13</sup> See, e.g., A. Atiq Rahman, Paulo Artaxo, Asfawossen Asrat & Andy Parker, *Developing Countries Must Lead on Solar Geoengineering Research*, 556 NATURE 22, 23–24 (2018).

<sup>14</sup> See William J. Ripple, Christopher Wolf, Thomas M. Newsome, Phoebe Barnard & William R. Moomaw, *World Scientists’ Warning of a Climate Emergency*, 70 BIOSCIENCE 8, 8 (2020) (open letter with more than 11,000 scientist signatories).

<sup>15</sup> See Fred Pearce, *Geoengineer the Planet? More Scientists Now Say It Must Be an Option*, YALE ENV’T 360 (May 29, 2019), <https://e360.yale.edu/features/geoengineer-the-planet-more-scientists-now-say-it-must-be-an-option> [<https://perma.cc/9SNJ-V8YN>].

<sup>16</sup> See IPCC, *supra* note 3, at 4–5.

Amid failure and a looming sense of emergency, national governments are quietly beginning to launch research programs on solar geoengineering.<sup>17</sup> In December 2019, Congress appropriated \$4 million to the National Oceanic and Atmospheric Administration (NOAA) to research the impacts of stratospheric aerosols on climate.<sup>18</sup> Congress instructed NOAA that the appropriation was for:

modeling, assessments, and, as possible, initial observations and monitoring of stratospheric conditions and the Earth's radiation budget, including the impact of the introduction of material into the stratosphere from changes in natural systems, increased air and space traffic, *proposals to inject material to affect climate, and the assessment of solar climate interventions*. Within these funds, the agreement further directs [NOAA's Office of Oceanic and Atmospheric Research (NOAA Research)] to improve the understanding of the impact of atmospheric aerosols on radiative forcing, as well as on the formation of clouds, precipitation, and extreme weather.<sup>19</sup>

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<sup>17</sup> See, e.g., Stuart McDill, 'Cloud Brightening' Experiment May Help Cool Great Barrier Reef, REUTERS (Apr. 22, 2020, 3:08 AM), <https://www.reuters.com/article/us-earth-day-reef-cooling/cloud-brightening-experiment-may-help-cool-great-barrier-reef-idUSKCN2240ZC> [<https://perma.cc/T4W8-AQXN>] (describing Australian research on marine cloud brightening to slow coral bleaching on the Great Barrier Reef); Graham Readfearn, *Coalition Backs 'Cloud-Brightening' Trial on Great Barrier Reef to Tackle Global Heating*, GUARDIAN (July 14, 2020, 1:30 PM), <https://www.theguardian.com/environment/2020/jul/15/coalition-backs-cloud-brightening-trial-on-great-barrier-reef-to-tackle-global-heating> [<https://perma.cc/A43F-6UAW>]; James Temple, *China Builds One of the World's Largest Geoengineering Research Programs*, MIT TECH. REV. (Aug. 2, 2017), <https://www.technologyreview.com/2017/08/02/4291/china-builds-one-of-the-worlds-largest-geoengineering-research-programs> [<https://perma.cc/7EZ8-5GRQ>] (describing China's program as "one of the largest federally funded geoengineering research programs in the world").

<sup>18</sup> See H. COMM. ON RULES, 116TH CONG., JOINT EXPLANATORY STATEMENT SUBMITTED BY MRS. LOWEY, CHAIRWOMAN OF THE HOUSE COMMITTEE ON APPROPRIATIONS REGARDING H.R. 1158: CONSOLIDATED APPROPRIATIONS ACT, 2020, DIVISION B – COMMERCE, JUSTICE, SCIENCE, AND RELATED AGENCIES APPROPRIATIONS ACT, 2020 17–18 (Dec. 17, 2019) [hereinafter JOINT EXPLANATORY STATEMENT], <https://docs.house.gov/billssthisweek/20191216/BILLS-116HR1158SA-JES-DIVISION-B.pdf> [<https://perma.cc/V52N-UX8Q>] (report accompanying congressional appropriations for fiscal year 2020 containing the relevant appropriation instructions to NOAA Research); Consolidated Appropriations Act, 2020, Pub. L. No. 116-93, 133 Stat. 2317, 2390–91 (2019) (containing the total FY2020 appropriation to NOAA and instructing the agency to follow the specific program designations within the Joint Explanatory Statement); see also CONG. RSCH. SERV., APPROPRIATIONS BILLS: WHAT IS REPORT LANGUAGE? 1 (2010) (explaining the legal relationship between enacted appropriations text and accompanying joint explanatory statements); Shuchi Talati, *A Small Provision in the FY20 Spending Package Deserves a Much Bigger Discussion*, UNION CONCERNED SCIENTISTS (Jan. 24, 2020, 2:36 PM), <https://blog.ucsusa.org/shuchi-talati/provision-in-fy20-spending-package-deserves-bigger-discussion> [<https://perma.cc/7JEU-8QZJ>].

<sup>19</sup> JOINT EXPLANATORY STATEMENT, *supra* note 18, at 17–18 (emphasis added).

The language is widely seen as the first federally funded and controlled initiative to investigate solar geoengineering.<sup>20</sup> These instructions could be fulfilled—and likely will be—through modeling and passive observation of the stratosphere to learn how it responds to aerosols introduced by natural and anthropogenic sources.<sup>21</sup> Scientists have long conducted research on these topics,<sup>22</sup> but Congress explicitly linked the project to “the assessment of solar climate interventions” rather than conventional climate science.<sup>23</sup> The questions explored go to the heart of solar geoengineering research needs.<sup>24</sup> Subsequent congressional reports on climate policy have also highlighted the need for research into solar geoengineering techniques, and subsequent appropriations will likely expand research funding for the program.<sup>25</sup> In short, this is a geoengineering research program.

These developments require concrete, practical thinking about geoengineering research governance. If solar geoengineering could indeed reduce some of the impacts of climate change, how should responsible research proceed? What risks—environmental, social, political—are involved in this research? How should those risks be managed? What tools are available to meet those goals?

This Essay considers the National Environmental Policy Act (NEPA)—a federal law requiring that federal agencies conduct an environmental review of certain proposed actions—as a means of answering these

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<sup>20</sup> See James Temple, *The US Government Has Approved Funds for Geoengineering Research*, MIT TECH. REV. (Dec. 20, 2019), <https://www.technologyreview.com/2019/12/20/131449/the-us-government-will-begin-to-fund-geoengineering-research> [<https://perma.cc/H5ST-K5KC>].

<sup>21</sup> See Emily Pontecorvo, *The Climate Policy Milestone That Was Buried in the 2020 Budget*, GRIST (Jan. 8, 2020), <https://grist.org/climate/the-climate-policy-milestone-that-was-buried-in-the-2020-budget> [<https://perma.cc/AP32-PZTP>] (quoting a NOAA official on how the funds likely will be used).

<sup>22</sup> See IPCC, CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS 573–75 (2013) [hereinafter IPCC, 2013] (summarizing the state of scientific knowledge on atmospheric aerosols and climate).

<sup>23</sup> See JOINT EXPLANATORY STATEMENT, *supra* note 18, at 18.

<sup>24</sup> See Douglas G. MacMartin & Ben Kravitz, *Mission-Driven Research for Stratospheric Aerosol Geoengineering*, 116 PROC. NAT’L ACAD. SCI. 1089, 1092 (2019) (identifying solar geoengineering research needs on “aerosol microphysics . . . , stratospheric mixing, stratospheric chemistry (principally ozone), aerosol radiative heating and its effects on water vapor concentrations and on stratospheric circulation, [and] the influence on cirrus”).

<sup>25</sup> H. SELECT COMM. ON THE CLIMATE CRISIS, 116TH CONG., SOLVING THE CLIMATE CRISIS: THE CONGRESSIONAL ACTION PLAN FOR A CLEAN ENERGY ECONOMY AND A HEALTHY, RESILIENT, AND JUST AMERICA 526 (2020) (calling on Congress “to establish a research program” on solar geoengineering); see also *FY21 Budget Outlook: National Oceanic and Atmospheric Administration*, AM. INST. PHYSICS (Oct. 15, 2020), <https://www.aip.org/fyi/2020/fy21-budget-outlook-national-oceanic-and-atmospheric-administration> [<https://perma.cc/6A4J-2ZAW>] (reporting that the U.S. House of Representatives enacted language that would increase the program’s budget to \$9 million for fiscal year 2021).

questions.<sup>26</sup> NEPA has substantial limitations for technological assessments, especially concerning their future speculative impacts on society.<sup>27</sup> But in the right hands, NEPA can be a serviceable tool to consider the environmental and social risks of this early solar geoengineering research program, seek expert advice on governance, and engage and educate the public on research.<sup>28</sup>

Specifically, NOAA should complete a programmatic environmental assessment (PEA) under NEPA on its research program on climate interventions.<sup>29</sup> PEAs help agencies consider the potential aggregate environmental impacts of a group of interrelated federal actions. They are most useful in instances like this one, where the impact of any one proposed action (i.e., research activity) would be too small to warrant environmental review. NOAA's PEA could consider the impact and significance of this federal research program, its relationship to other research activities on climate and solar geoengineering, and its potential impact on the physical environment. It could then be incorporated into a NEPA analysis of individual projects or experiments, all of which would otherwise evade environmental assessment entirely due to their de minimis impacts.<sup>30</sup> A PEA would provide at least some acknowledgment, assessment, and ownership of the risks at hand.

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<sup>26</sup> See 42 U.S.C. §§ 4321–4335 (2012). This Essay builds on an analysis published in a blog post on *Legal Planet* in February 2020. Charles Corbett, *Maxing Out NEPA: Environmental Review of Early Solar Geoengineering Field Research*, LEGAL PLANET (Feb. 25, 2020), <https://legal-planet.org/2020/02/25/maxing-out-nepa-environmental-review-of-early-solar-geoengineering-field-research> [<https://perma.cc/64MT-4J52>].

<sup>27</sup> See Albert C. Lin, *Technology Assessment 2.0: Revamping Our Approach to Emerging Technologies*, 76 BROOK. L. REV. 1309, 1334–38 (2011); see also, e.g., U.S. GOV'T ACCOUNTABILITY OFF., GAO-10-903, CLIMATE CHANGE: A COORDINATED STRATEGY COULD FOCUS FEDERAL GEOENGINEERING RESEARCH AND INFORM GOVERNANCE EFFORTS (2010) (high-level technological assessment of carbon dioxide removal and solar geoengineering technologies).

<sup>28</sup> This Essay does not consider deployment governance or governance of large-scale research with significant environmental impacts because those questions are largely premature. Planned and foreseeable research would have a vanishingly small impact on the physical environment. See MacMartin & Kravitz, *supra* note 24, at 1089–90.

<sup>29</sup> See Memorandum from Michael Boots, Council on Env't Quality, to Heads of Fed. Dep'ts & Agencies on Effective Use of Programmatic NEPA Revs. (Dec. 18, 2014), [https://www.energy.gov/sites/prod/files/2016/05/f31/effective\\_use\\_of\\_programmatic\\_nepa\\_reviews\\_18\\_dec2014.pdf](https://www.energy.gov/sites/prod/files/2016/05/f31/effective_use_of_programmatic_nepa_reviews_18_dec2014.pdf) [<https://perma.cc/PNG7-YKQR>] (providing an overview of NEPA and discussing the relationship between NEPA and PEAs).

<sup>30</sup> See *infra* text accompanying notes 98–122. The proposed PEA is thus narrower, more focused on near-term research, and more in line with NOAA's current NEPA practices than other geoengineering governance proposals that would make use of NEPA. Cf. Albert C. Lin, *The Missing Pieces of Geoengineering Research Governance*, 100 MINN. L. REV. 2509, 2556–65 (2016) (discussing how environmental impact statements under NEPA “often overlook indirect, cumulative, or programmatic effects”).

Admittedly, early-stage solar geoengineering research activities would have little impact on the physical environment—far below what normally triggers NEPA review.<sup>31</sup> But the experiments would advance understanding of technologies that could alter the planet’s natural systems in ways unprecedented in terms of scale, impact, and intentionality. NEPA guidance makes it clear that “extraordinary” or “highly controversial” government actions call for a more searching review.<sup>32</sup> This is the case here. Moreover, the public should be allowed to weigh in on this development and receive notice of the risks it entails.

Furthermore, besides a handful of exceptions, solar geoengineering research has been limited to lab experiments and computer modeling by private research teams.<sup>33</sup> A national government launching its own climate engineering “assessment” program raises the stakes. This seems especially so given the national government in question is the United States, one of the few countries that could plausibly spearhead global deployment of solar geoengineering. At the same time, other research institutions, such as Harvard University, are likely to go forward with their own field experiments on the subject.<sup>34</sup> Some of these experiments could require federal approval<sup>35</sup> and investigate questions closely related to NOAA’s research objectives.<sup>36</sup> A PEA would allow the U.S. government to simultaneously, and authoritatively, consider the impacts of all research activities potentially occurring under its jurisdiction.

Ideally, Congress would lead public deliberation on solar geoengineering research by holding hearings and debating legislation, rather than leaving action to an administrative agency. Congress, however, as it so often does on environmental issues, short-circuited its deliberative processes and created this solar geoengineering research program through an obscure

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<sup>31</sup> See *infra* text accompanying notes 98–122.

<sup>32</sup> See *infra* text accompanying notes 123–29.

<sup>33</sup> See IPCC, *supra* note 3, at 351–52 (explaining that “global field experiments have not been conducted and most of the knowledge about SRM is based on imperfect model simulations and some natural analogues”).

<sup>34</sup> See *Framework, Deliverables, and Timeline*, SCOPEX ADVISORY COMM., <https://scopexac.com/framework-deliverables-and-timeline/> [<https://perma.cc/F4H5-88QQ>].

<sup>35</sup> See *id.*; see also John A. Dykema, David W. Keith, James G. Anderson & Debra Weisenstein, *Stratospheric Controlled Perturbation Experiment: A Small-Scale Experiment to Improve Understanding of the Risks of Solar Geoengineering*, 372 PHIL. TRANSACTIONS ROYAL SOC’Y A, Dec. 28, 2014, at 16 (describing coordination with the FAA in the context of risk mitigation).

<sup>36</sup> See 33 U.S.C. § 893(a)–(b) (NOAA Research’s organic statute); see also *About the Climate Program Office*, NOAA CLIMATE PROGRAM OFF., <https://cpo.noaa.gov/Who-We-Are/About-CPO> [<https://perma.cc/LF57-J4M3>].

appropriation.<sup>37</sup> The duty to facilitate public engagement hence falls to the agency tasked with carrying this research out. Legitimacy is one reason this public engagement is worthwhile: thoughtful and open consideration of a solar geoengineering research program, subject to judicial review, would better cement the government's claim of authority to start one.<sup>38</sup> Doing so would also satisfy NEPA's core purpose, which is to spur *ex ante* consideration of the environmental risks of major federal actions.<sup>39</sup> Solar geoengineering, if deployed, would have environmental impacts of a magnitude that few other human endeavors have matched. Surely this merits some environmental assessment at the outset.

Part I discusses the relationship between solar geoengineering research and climate modeling. Part II then provides an overview of the NEPA process and the opportunities it provides for governing federal geoengineering research. Finally, Part III illustrates why an agency should want to use its discretion here to engage in expansive NEPA review.

## I. EARLY FIELD RESEARCH INTO SOLAR GEOENGINEERING

Among solar geoengineering proposals, the best understood and most discussed is stratospheric aerosol injection (SAI), as considered in the appropriations language.<sup>40</sup> A SAI program would introduce a thin "veil" of aerosols into the stratosphere that, while suspended there, would reflect away a small portion of incoming sunlight.<sup>41</sup> Less solar energy would enter the planet's climate system, causing it to cool. Large-scale deployment of SAI could deliver a substantial cooling effect, sustained for about a year or more

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<sup>37</sup> See JOINT EXPLANATORY STATEMENT, *supra* note 18, at 17–18; see also Richard J. Lazarus, *Congressional Descent: The Demise of Deliberative Democracy in Environmental Law*, 94 GEO. L.J. 619, 632–33 (2006).

<sup>38</sup> See Mark Seidenfeld, *A Civic Republican Justification for the Bureaucratic State*, 105 HARV. L. REV. 1511, 1528–33, 1547–50 (1992); Tina Nabatchi, *Addressing the Citizenship and Democratic Deficits: The Potential of Deliberative Democracy for Public Administration*, 40 AM. REV. PUB. ADMIN. 376, 376–77 (2010).

<sup>39</sup> See *Calvert Cliffs' Coordinating Comm., Inc. v. U.S. Atomic Energy Comm'n*, 449 F.2d 1109, 1112 (D.C. Cir. 1971) ("Perhaps the greatest importance of NEPA is to require the Atomic Energy Commission and other agencies to *consider* environmental issues just as they consider other matters within their mandates.").

<sup>40</sup> See JOINT EXPLANATORY STATEMENT, *supra* note 18, at 17–18; see also IPCC, *supra* note 3, at 348 tbl.4.7 (providing an overview of solar geoengineering technologies, including stratospheric aerosol injection (SAI)).

<sup>41</sup> See, e.g., IPCC, *supra* note 3, at 349–52 cross-ch. box 10; Oliver Morton, *Cutting Loose the Climate Future from the Carbon Past*, ANTHROPOCENE (July 2017), <https://www.anthropocenemagazine.org/geoengineering> [<https://perma.cc/6DAT-8JSP>].



after injection, at relatively low direct costs.<sup>42</sup> Yet much scientific uncertainty remains on the character, distribution, and controllability of SAI's effects.<sup>43</sup>

As with other areas of climate science, modeling is central to improving knowledge of SAI.<sup>44</sup> Climate modeling is similar to weather forecasting but is concerned with much larger scales of space and time.<sup>45</sup> Climate models use many lines of computer code to calculate past or future climate states based on the inputs and assumptions fed into them. These models are then used to study the climate system, the natural and human processes that influence it, how it might behave within different greenhouse gas emissions scenarios, and more. Current modeling shows that SAI is a technically feasible climate cooling mechanism.<sup>46</sup>

Yet modeling has a few important limitations.<sup>47</sup> First, models rely on scientific equations to represent the natural processes that drive climate. A climate model's reliability will hence suffer where scientific understanding is wrong or especially incomplete.<sup>48</sup> Second, climate models run on limited computing power. A computer can complete only so many calculations in a second, meaning scientists must simplify the world depicted in their models.<sup>49</sup> Simplifications can help models incorporate parts of the climate system that are too complex, too small, or too poorly understood to reliably calculate. As said by one climate scientist: "Models are not right or wrong; they're always wrong. They're always approximations. The question you have to ask is whether a model tells you more information than you would have had otherwise."<sup>50</sup>

SAI modeling to date has used somewhat simple assumptions. For example, researchers have simulated SAI deployment by reducing the solar

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<sup>42</sup> See Michael B. Gerrard, *Introduction and Overview*, in CLIMATE ENGINEERING AND THE LAW 1, 2–3 (Michael B. Gerrard & Tracy Hester eds., 2018).

<sup>43</sup> See MacMartin & Kravitz, *supra* note 24, at 1090, 1091 fig.2.

<sup>44</sup> See *id.* at 1091–92.

<sup>45</sup> *Q&A: How Do Climate Models Work?*, CARBONBRIEF (Jan. 15, 2018, 8:30 AM), <https://www.carbonbrief.org/qa-how-do-climate-models-work> [<https://perma.cc/47JC-B8YP>]. One way of defining "climate," after all, is average weather over a given period. REYNOLDS, *supra* note 7, at 8.

<sup>46</sup> IPCC, *supra* note 3, at 348–49, 351–52.

<sup>47</sup> See *Q&A: How Do Climate Models Work?*, *supra* note 45.

<sup>48</sup> *Cf.* IPCC, 2013, *supra* note 22, at 743–45 (describing advances and limitations in climate modeling).

<sup>49</sup> This can be done through "coarser" spatial resolutions or through larger time jumps between climate states. It is also done by using "parameterisations," where a model uses fixed values to approximate certain phenomena rather than calculating them out. Examples of phenomena parameterized in models include scattering of sunlight by atmospheric aerosols, reflection and absorption of energy by clouds, and surface reflectivity. See *Q&A: How Do Climate Models Work?*, *supra* note 45.

<sup>50</sup> Gavin Schmidt, *The Emergent Patterns of Climate Change*, TED (Mar. 2014), [https://www.ted.com/talks/gavin\\_schmidt\\_the\\_emergent\\_patterns\\_of\\_climate\\_change](https://www.ted.com/talks/gavin_schmidt_the_emergent_patterns_of_climate_change) [<https://perma.cc/5Q23-4U6A>].

input—turning down the sun, essentially—and seeing what happens.<sup>51</sup> These findings should be treated as simple sketches of deployment, rather than accurate predictions. But “simple” does not mean bad or worthless. Climate models themselves began as somewhat limited analytical tools, gradually adding more complex interactions as scientific understanding grew and computing power improved.<sup>52</sup> This progress has been essential to improving knowledge of the climate system and the impact of greenhouse gas emissions caused by humans.<sup>53</sup> Furthermore, the projections of these climate models, starting in the 1970s, have proven generally accurate when compared to observational data collected later.<sup>54</sup>

FIGURE 1: THE WORLD IN GLOBAL CLIMATE MODELS

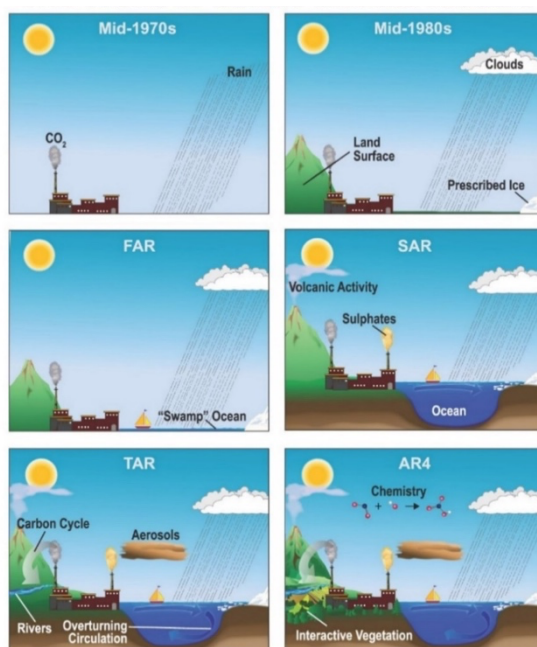


Fig. 1, showing the gradual evolution of climate models as they included more aspects of the climate system, beginning with CO<sub>2</sub>, solar energy, and rain, eventually adding land surfaces, ocean, sulfates, volcanic activity, clouds, aerosols, biogenic processes, and more.<sup>55</sup>

<sup>51</sup> See MacMartin & Kravitz, *supra* note 24, at 1091.

<sup>52</sup> See IPCC, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS 98 (2007) [hereinafter IPCC, 2007]; see also IPCC, 2013, *supra* note 22, at 743 (reporting continued improvements in climate modeling).

<sup>53</sup> See IPCC, 2007, *supra* note 52, at 98.

<sup>54</sup> See Q&A: How Do Climate Models Work?, *supra* note 45.

<sup>55</sup> IPCC, 2007, *supra* note 52, at 99 fig.1.2.

Just as models improved climate depictions through “detailed laboratory measurements, observational experiments and theoretical analyses,” so too can they be improved for investigating SAI.<sup>56</sup> Accordingly, initial field research into solar geoengineering would seek to answer basic questions of how the stratosphere behaves, how materials are distributed through it, and how stratospheric changes influence the troposphere below—the turbulent layer of the atmosphere where weather happens and where we humans live.<sup>57</sup> The data gathered would help improve models for depicting future climate change and hypothetical climate interventions. However, opposition to SAI and SAI-related research initiatives is not driven by harms to the physical environment; it is driven by concern over the potential social, political, and indirect consequences further down the road.

Considering a real-world example may help clarify why this is the case and how this science works in practice. A team at Harvard University is developing an SAI field experiment called the Stratospheric Controlled Perturbation Experiment (SCoPEX).<sup>58</sup> SCoPEX aims to improve the understanding of SAI by studying how aerosols physically disperse when released into the stratosphere and the composition of their subsequent chemistry.<sup>59</sup> To gather this data, SCoPEX will release a weather balloon into the upper atmosphere carrying a small array of observation equipment.<sup>60</sup> Upon reaching altitude, the balloon will spray a few kilograms of material—water, calcium carbonate, and sulfates are candidates<sup>61</sup>—to observe their

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<sup>56</sup> Cf. *id.* at 98.

<sup>57</sup> See MacMartin & Kravitz, *supra* note 24, at 1091–92.

<sup>58</sup> See Keutsch Rsch. Grp., *Stratospheric Controlled Perturbation Experiment (SCoPEX)*, HARV. U., <https://projects.iq.harvard.edu/keutschgroup/scopex> [<https://perma.cc/UPT9-PN2Z>].

<sup>59</sup> See Dykema et al., *supra* note 35, at 5–6.

<sup>60</sup> Keutsch Rsch. Grp., *supra* note 58.

<sup>61</sup> Some readers may wonder why researchers are investigating sulfates as a potential chemical agent for SAI; the Clean Air Act regulates sulfur dioxide as a criteria pollutant, and scientists have long established the relationship between sulfur dioxide and acid rain, ozone layer depletion, and human respiratory problems. See Renee Rico, *The U.S. Allowance Trading System for Sulfur Dioxide: An Update on Market Experience*, 5 ENV'T & RES. ECON. 115, 116–17 (1995); Guy Brasseur & Claire Granier, *Mount Pinatubo Aerosols, Chlorofluorocarbons, and Ozone Depletion*, 257 SCIENCE 1239, 1239 (1992); see also Review of the Primary National Ambient Air Quality Standards for Sulfur Oxides, 84 Fed. Reg. 9866, 9874–75 (Mar. 18, 2019) (to be codified at 40 C.F.R. pt. 50). But scientists have also long studied the cooling effect of atmospheric sulfates, such as the global cooling associated with large volcanic eruptions and the regional cooling from industrial emissions. See, e.g., Brasseur & Granier, *supra*, at 1239; B. H. Samset, M. Sand, C. J. Smith, S. E. Bauer, P. M. Forster, J. S. Fuglestad, S. Osprey & C.-F. Schleussner, *Climate Impacts from a Removal of Anthropogenic Aerosol Emissions*, 45 GEOPHYSICAL RSCH. LETTERS 1020, 1020, 1026 (2018). Further, scientists have a good understanding of how sulfates cycle through the atmosphere, soils, oceans, and ecosystems. See generally P. Brimblecombe, *The Global Sulfur Cycle*, in 10 TREATISE ON GEOCHEMISTRY 559 (David M. Karl & William H. Schlesinger eds., 2d ed. 2014) (summarizing the state of scientific knowledge on the sulfur cycle). Sulfur, fittingly, is the devil

behavior, chemistry, and influence on the surrounding light and air.<sup>62</sup> These observations will help researchers improve modeling of ozone depletion, aerosol longevity, and more, which in turn will help models render more accurate depictions of SAI deployment.<sup>63</sup>

The opposition of some stakeholders to SCoPEX and similar field experiments has little to do with their direct impacts on the physical environment. If SCoPEX were to release sulfates, the amount of material released would be very small, much less than what a commercial airplane emits during “one minute of flight.”<sup>64</sup> It would also be released at a very great height, meaning the material would wash out over a far greater space and become much more diluted by the time it reaches the surface as compared to industrial sources.<sup>65</sup> If SCoPEX were to use sulfates, it would have no lasting or significant impact on the physical environment.

Similar to the controversy over early research into genetically modified organisms, opponents’ concern is driven by potential consequences further down the road.<sup>66</sup> Critics warn of a *slippery slope*, where early research would inexorably commit governments to bigger experiments, development of the technology, and, ultimately, deployment.<sup>67</sup> They argue solar geoengineering could cause *moral hazard*, in that research would signal policymakers and business leaders to take emissions cuts even less seriously than they already do.<sup>68</sup> Some consider it *intrinsically wrong* to tamper with nature this way, or that SAI’s deployment would be *inevitably unjust*, given its global impacts and centralized control.<sup>69</sup>

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we know. See REYNOLDS, *supra* note 7, at 20. Some have proposed calcium carbonate as an alternative chemical for SAI deployment given sulfates’ health and environmental impacts. See David W. Keith, Debra K. Weisenstein, John A. Dykema & Frank N. Keutsch, *Stratospheric Solar Geoengineering Without Ozone Loss*, 113 PROC. NAT’L ACAD. SCI. 14910, 14910 (2016).

<sup>62</sup> Keutsch Rsch. Grp., *supra* note 58.

<sup>63</sup> See Dykema et al., *supra* note 35, at 6.

<sup>64</sup> Keutsch Rsch. Grp., *supra* note 58. A kilogram or so is several orders of magnitude smaller than the emissions levels that harm human health and the environment. See EPA, INTEGRATED SCIENCE ASSESSMENT FOR SULFUR OXIDES – HEALTH CRITERIA 2-3 fig.2-1, 2-4 fig.2-2 (2017) (reporting hundreds of thousands of tons of sulfur dioxide emissions annually in the United States from fossil fuel combustion, concentrated in the Midwest and Mid-Atlantic).

<sup>65</sup> See Peter J. Irvine, Ben Kravitz, Mark G. Lawrence, Dieter Gerten, Cyril Caminade, Simon N. Gosling, Erica J. Hendy, Belay T. Kassie, W. Daniel Kissling, Helene Muri, Andreas Oschlies & Steven J. Smith, *Towards a Comprehensive Climate Impacts Assessment of Solar Geoengineering*, 5 EARTH’S FUTURE 93, 97 (2017).

<sup>66</sup> See Stefan Schäfer & Sean Low, *The Discursive Politics of Expertise: What Matters for Geoengineering Research and Governance?*, in WORK IN PROGRESS: ECONOMY AND ENVIRONMENT IN THE HANDS OF EXPERTS (forthcoming) (manuscript at 1–2) (Frank Trentmann, Anna Barbara Sum & Manuel Rivera eds., 2018).

<sup>67</sup> See *id.*; see also ROYAL SOC’Y, *supra* note 9, at 39 (discussing risk of technology “lock-in”).

<sup>68</sup> ROYAL SOC’Y, *supra* note 9, at 37.

<sup>69</sup> See *id.* at 45.

Regardless of the specific activities NOAA Research plans to pursue, Congress's appropriation is intended, in part, for the "assessment of solar climate interventions."<sup>70</sup> Research thus heads down this purportedly slippery, morally hazardous, intrinsically wrong path. The next step, then, is to ask what governance is appropriate in light of these serious concerns.

## II. NEPA: PURPOSE, DESIGN, AND LIMITATIONS

The purpose of NEPA is to integrate environmental considerations into federal agency decision-making and to assure the public that the agency has considered those impacts.<sup>71</sup> It does so by requiring federal agencies to describe and analyze the environmental impacts of proposed government actions.<sup>72</sup> The bulk of impact analysis occurs through devising reasonable alternatives to the proposed action and comparing the environmental impacts between the different pathways. The agency must also describe the final action and explain why it was chosen.

The Council of Environmental Quality's (CEQ) implementing regulations for NEPA—and their interpretation by federal courts—have created an elaborate administrative scheme for NEPA's implementation.<sup>73</sup> A few key terms are below:

- *Environmental Assessment (EA)*: Environmental review document prepared if the agency is unsure whether the proposal has significant

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<sup>70</sup> JOINT EXPLANATORY STATEMENT, *supra* note 18, at 18.

<sup>71</sup> Weinberger v. Cath. Action of Haw., 454 U.S. 139, 143 (1981).

<sup>72</sup> Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, 46 Fed. Reg. 18,026, 18,026–29 (Mar. 17, 1981) (describing requirements of the environmental review process), *rescinded in part* by National Environmental Policy Act Regulations; Incomplete or Unavailable Information, 51 Fed. Reg. 15,618, 15,619–21 (Apr. 25, 1986) (striking instructions regarding worst-case scenario analysis).

<sup>73</sup> CEQ promulgates regulations instructing federal agencies on how to complete environmental review processes that comply with NEPA. It has recently finalized revisions to NEPA's implementing regulations. See Update to the Regulations Implementing the Procedural Provisions of the National Environmental Policy Act, 85 Fed. Reg. 43,304 (July 16, 2020). Among other changes, it controversially limits which government actions trigger NEPA's requirements, narrows the range of alternative actions agencies must consider, and expands the role of nongovernment project proponents in developing environmental analyses. See Rachael L. Lipinski, Jonathan D. Simon, Molly A. Lawrence & Joseph B. Nelson, *CEQ Issues Final Rule to Modernize NEPA Regulations*, NAT'L L. REV. (July 20, 2020), <https://www.natlawreview.com/article/ceq-issues-final-rule-to-modernize-nepa-regulations> [https://perma.cc/K63G-M5D3]. Environmental groups quickly filed suit challenging the new implementing rules and seeking vacatur. See *Nationwide Coalition Sues to Defend the People's Environmental Law*, EARTHJUSTICE (July 29, 2020), <https://earthjustice.org/news/press/2020/nationwide-coalition-sues-to-defend-the-peoples-environmental-law> [https://perma.cc/SH47-NMQJ]. Given litigation uncertainties and new priorities of the Biden administration, this Essay looks to both sets of regulations. See Kelsey Brugger, *Biden CEQ Pick Signals NEPA Changes*, E&E NEWS: GREENWIRE (Dec. 21, 2020), <https://www.eenews.net/stories/1063721221> [https://perma.cc/R24K-7DPV].

environmental impacts, or where a proposal without significant impacts is unusual or extraordinary;<sup>74</sup>

- *Environmental Impact Statement (EIS)*: In-depth environmental review document prepared if the agency determines the proposed action will have significant impacts;<sup>75</sup>
- *Programmatic NEPA Review (PEA or PEIS)*: A broad, high-level EA or EIS that examines the big picture environmental consequences of a policy, often covering many interrelated federal actions that may otherwise evade environmental review;<sup>76</sup> and
- *Categorical Exclusion (CX)*: Frequent or routine agency action determined in advance to have no significant environmental impacts, therefore presenting no need to prepare an EA or an EIS.<sup>77</sup>

Agencies retain discretion in how to structure their NEPA analyses' scope, detail, and outcome, provided they take a "hard look" at the environmental consequences of their proposals.<sup>78</sup> For NEPA, a "hard look" requires the agency to gather sufficient information about the proposal's likely environmental impacts, weigh the risks and benefits in good faith, and explain the reasoning behind its final conclusion.<sup>79</sup> Agencies also submit their analyses to a public notice and comment process, allowing for substantial input by interested members of the public.<sup>80</sup> Courts will defer to those determinations so long as they find them complete and reasonable.<sup>81</sup> If the court finds the analysis insufficient, though, it may remand the NEPA process back to the agency to correct the deficiency.<sup>82</sup> It may also enjoin the proposed action in the meantime, depending on the circumstances of the case.<sup>83</sup>

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<sup>74</sup> See James W. Spensley, *National Environmental Policy Act*, in ENVIRONMENTAL LAW HANDBOOK 681, 695–96 (Thomas F. P. Sullivan ed., 24th ed. 2019).

<sup>75</sup> See *id.* at 696–706.

<sup>76</sup> See Memorandum from Michael Boots, *supra* note 29, at 6–7.

<sup>77</sup> See Spensley, *supra* note 74, at 690–91.

<sup>78</sup> *Kleppe v. Sierra Club*, 427 U.S. 390, 410 n.21 (1976) (quoting *NRDC v. Morton*, 458 F.2d 827, 838 (1972)). The Administrative Procedure Act (APA) provides the cause of action and standard of review in NEPA cases. See *Marsh v. Or. Nat. Res. Council*, 490 U.S. 360, 375 (1989); see also *Citizens to Pres. Overton Park, Inc. v. Volpe*, 401 U.S. 402, 415–17 (1971) (elaborating on the requirements of arbitrary and capricious review under the APA).

<sup>79</sup> Memorandum from Michael Boots, *supra* note 29, at 32; see also Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, 46 Fed. Reg. 18,026, 18,032 (Mar. 17, 1981).

<sup>80</sup> COUNCIL ON ENV'T QUALITY, EXEC. OFF. OF THE PRESIDENT, A CITIZEN'S GUIDE TO THE NEPA: HAVING YOUR VOICE HEARD 25 (2007).

<sup>81</sup> *Kleppe*, 427 U.S. at 412.

<sup>82</sup> See *Citizens to Pres. Overton Park, Inc.*, 401 U.S. at 420–21 (clarifying the requirements of arbitrary and capricious review under the APA and providing a remedy).

<sup>83</sup> See *Monsanto Co. v. Geertson Seed Farms*, 561 U.S. 139, 156–57 (2010).

NEPA is said to be procedural rather than substantive.<sup>84</sup> It requires rigorous contemplation of environmental impacts but does not mandate an environmentally friendly final decision by the agency.<sup>85</sup> NEPA does not require agencies to commit to mitigation plans to limit the environmental impacts of the proposed action.<sup>86</sup> Further, agencies need only consider the reasonably foreseeable effects of their actions, not the related actions of others outside their control.<sup>87</sup> Also excluded are psychological harms the proposal may cause, absent a direct connection to a significant physical change in the environment.<sup>88</sup> Similarly, policy objections to a proposal or a proposal's symbolic significance need not be analyzed.<sup>89</sup>

Despite these constraints, NEPA has been successful at compelling agencies to produce thorough, thoughtful analyses of the environmental consequences of major government proposals.<sup>90</sup> It also provides a forum for impacted communities to raise their concerns to the federal government with the assurance they will be heard.<sup>91</sup> NEPA has been justifiably criticized for being overly burdensome at times, as in the context of analyses for some proposals by the U.S. Department of Housing and Urban Development (HUD),<sup>92</sup> but on the whole, NEPA has been rightfully credited with promoting a more cautious and conscientious attitude in government toward the environment.<sup>93</sup>

### III. IMPLEMENTING NEPA FOR SOLAR GEOENGINEERING RESEARCH

Basic scientific research is often a poor fit for NEPA review because of its low physical impact on the environment, uncertain consequences, and available CXs. NOAA, however, retains discretion to engage in a more thorough environmental review in light of “extraordinary” or “highly

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<sup>84</sup> *Vt. Yankee Nuclear Power Corp. v. NRDC*, 435 U.S. 519, 558 (1978).

<sup>85</sup> *Strycker's Bay Neighborhood Council, Inc. v. Karlen*, 444 U.S. 223, 227–28 (1980).

<sup>86</sup> *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 353 (1989).

<sup>87</sup> *Dep't of Transp. v. Pub. Citizen*, 541 U.S. 752, 767 (2004).

<sup>88</sup> *Metro. Edison Co. v. People Against Nuclear Energy*, 460 U.S. 766, 776–77 (1983).

<sup>89</sup> *See id.* at 777 n.12.

<sup>90</sup> *See* COUNCIL ON ENV'T QUALITY, EXEC. OFF. OF THE PRESIDENT, LENGTH OF ENVIRONMENTAL IMPACT STATEMENTS (2013–2017) 1 (2019) [hereinafter CEQ] (reporting the average page length of environmental impact statements across agencies to be 669 pages and the median to be 445 pages).

<sup>91</sup> Spensley, *supra* note 74, at 702.

<sup>92</sup> *See* CEQ, *supra* note 90, at 6 fig.3 (showing HUD environmental impact statements more than double the page length of the average page length of statements across all agencies).

<sup>93</sup> *See* Bradley C. Karkkainen, *Toward a Smarter NEPA: Monitoring and Managing Government's Environmental Performance*, 102 COLUM. L. REV. 903, 905 (2002) (“NEPA is without question the most widely emulated of the major U.S. environmental laws . . . inspir[ing] . . . numerous progeny around the globe . . .”).

controversial” activities.<sup>94</sup> A PEA would be appropriate in anticipation of federal research on solar geoengineering given the profound risks and ethical issues it raises.

#### A. Legal Bars to Compelling NEPA Review

Scientific research tends to be characterized under NEPA as an activity that lacks environmental impacts. With NEPA, “Congress was talking about the physical environment—the world around us, so to speak.”<sup>95</sup> NEPA thus requires a “reasonably close causal relationship between a change in the physical environment and the effect at issue” to compel environmental review.<sup>96</sup> The results of scientific investigation are often uncertain, and even more unknown are the ways in which government actors and private parties might put that knowledge to use. As the National Science Foundation says in its implementing regulations for NEPA, “the long term effect of the accumulation of human knowledge is . . . basically speculative and unknowable in advance.”<sup>97</sup> Basic scientific research therefore rarely produces the direct, physical environmental impacts typically analyzed under NEPA.

The most pressing concerns regarding solar geoengineering research also rarely present a clear basis for triggering NEPA’s requirements. Worries about a “slippery slope,” for example, rely on a highly speculative causal relationship between research and deployment. A few hypotheticals show why: Imagine that an early, low-impact field experiment discovers that atmospheric heating associated with aerosol dispersion is far greater and far more uneven than once thought.<sup>98</sup> Subsequent improved modeling based on this data shows this heating would, in a global SAI deployment scenario, likely cause long-term drought over major agricultural regions around the world. Such a discovery could very well kill enthusiasm for solar geoengineering leading to the idea’s abandonment and a lack of resulting physical impact. Not doing research, conversely, could conceal this drawback and needlessly preserve the threat of emergency SAI deployment.

Alternatively, solar geoengineering field research could uncover no new drawbacks within climate modeling of deployment scenarios. Yet, future decision-makers may still find the unknowns of SAI too daunting,

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<sup>94</sup> See *infra* text accompanying notes 121–135.

<sup>95</sup> *Metro. Edison Co. v. People Against Nuclear Energy*, 460 U.S. 766, 772 (1983).

<sup>96</sup> *Id.* at 774.

<sup>97</sup> 45 C.F.R. § 640.3(b) (2019); see also Albert C. Lin, *U.S. Law, in CLIMATE ENGINEERING AND THE LAW* 154, 157–58 (Michael B. Gerrard & Tracy Hester eds., 2018).

<sup>98</sup> See OLIVER MORTON, *THE PLANET REMADE: HOW GEOENGINEERING COULD CHANGE THE WORLD* 111 (2015) (describing stratospheric heating).



preferring the dangers and diffuse accountability of a greenhouse Earth to a geoengineered one, again, producing no direct physical impact. Or more optimistically, aggressive efforts on climate mitigation, adaptation, and carbon removal could obviate the need to consider deploying SAI at all.

NEPA requires a “reasonably close causal relationship” between proposed action and potential impact, akin to “proximate cause from tort law.”<sup>99</sup> The chain of causation within slippery slope arguments assumes too much to meet that standard. It leaps from field research to modeling, to subsequent experimentation, to technological development, and, finally, to deployment, all against an assumed backdrop of worsening climate harms, lackluster mitigation, and high risk tolerance by political decision-makers. Any one of these assumptions may be plausible, but strung together, they make a future scenario too flimsy to compel NEPA review.

Supposing for the sake of argument that the causal relationship is proximate, NOAA Research would still have no authority to deploy SAI and no power to stop others from doing so. Such third-party actions would be beyond NOAA Research’s jurisdiction and therefore beyond the scope of what the agency must consider in NEPA review.<sup>100</sup> This is the same reason why moral hazard concerns on their own would not trigger NEPA review of solar geoengineering research. Moral hazard arguments warn that governments will delay mitigation and climate adaptation efforts out of the belief that solar geoengineering will sufficiently protect against climate risk.<sup>101</sup> NOAA Research, however, has no authority to regulate greenhouse gas emissions or lead adaptation efforts. It cannot delay what it cannot control, and it, therefore, need not analyze moral hazard risk.

Left then to trigger NEPA review are the direct physical impacts of research. But the environmental impacts associated with current, planned, and foreseeable solar geoengineering research are minimal: a computer model running in a lab, a weather balloon released into the sky. The Supreme Court’s 1983 decision in *Metropolitan Edison Co. v. People Against Nuclear Energy*<sup>102</sup> is on point here. At issue was the nuclear power plant on Three Mile Island, Pennsylvania, the very same plant where in 1979 a nuclear reactor appeared on the brink of a catastrophic meltdown and sparked a national panic.<sup>103</sup> After the Three Mile Island incident, the Nuclear

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<sup>99</sup> Dep’t of Transp. v. Pub. Citizen, 541 U.S. 752, 767 (2004) (citing *Metro. Edison Co.*, 460 U.S. at 774).

<sup>100</sup> See *id.*

<sup>101</sup> See Albert C. Lin, *Does Geoengineering Present a Moral Hazard?*, 40 *ECOLOGY L.Q.* 673, 678 (2013).

<sup>102</sup> 460 U.S. 766 (1983).

<sup>103</sup> See N.Y. Times, *Three Mile Island Documentary: Nuclear Power’s Promise and Peril*, YOUTUBE (Apr. 29, 2014), [https://www.youtube.com/watch?v=\\_0P9S4F4KpQ](https://www.youtube.com/watch?v=_0P9S4F4KpQ) [<https://perma.cc/48JA-9LPG>].

Regulatory Commission shut down all reactors at the plant and conducted a safety review.<sup>104</sup> The Commission determined that a nuclear reactor not involved in the incident could resume operations; an EA accompanying the decision concluded no EIS was required.<sup>105</sup> Antinuclear group, People Against Nuclear Energy (PANE), sued, arguing a supplemental EIS was required to assess the mental anguish and anxiety in surrounding communities over renewed fears of a nuclear meltdown.<sup>106</sup>

Justice Rehnquist, writing for the Court, disagreed. The “*risk* of an accident is not an effect on the physical environment. A risk is, by definition, unrealized in the physical world.”<sup>107</sup> The causal chain proposed by PANE—resumption of plant operations, perception of risk, and experiencing psychological harm—therefore exceeded “the reach of NEPA.”<sup>108</sup> Justice Rehnquist added:

[T]he question whether the gains from any technological advance are worth its attendant risks may be an important public policy issue. Nonetheless, it is quite different from the question whether the same gains are worth a given level of alteration of our physical environment or depletion of our natural resources. The latter question rather than the former is the central concern of NEPA.<sup>109</sup>

With this, *Metropolitan Edison Co.* pushes back against antinuclear activists’ use of NEPA litigation as a tactic to slow nuclear energy projects.<sup>110</sup> It recalls the Court’s decision in *Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council, Inc.*, also written by Justice Rehnquist, rejecting arguments for a more elaborate environmental review of a nuclear power plant.<sup>111</sup> The Court viewed these claims as brought out of steadfast opposition to nuclear energy rather than genuine concern for environmental review.<sup>112</sup> “Congress has made a choice to at least try nuclear energy . . . . The fundamental policy questions appropriately resolved in Congress and in the state legislatures are *not* subject to reexamination in the federal courts.”<sup>113</sup> NEPA processes are thus no place to derail Congress’s major policy

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<sup>104</sup> *Metro. Edison Co.*, 460 U.S. at 769–70.

<sup>105</sup> *Id.* at 770 n.4.

<sup>106</sup> *See id.* at 771.

<sup>107</sup> *Id.* at 775.

<sup>108</sup> *Id.*; *see also id.* at 779 (Brennan, J., concurring) (adding psychological harm associated with “direct sensory impact of a change in the physical environment” would be “cognizable under NEPA”).

<sup>109</sup> *Id.* at 776 (majority opinion).

<sup>110</sup> *See id.* at 777 & n.12.

<sup>111</sup> 435 U.S. 519 (1978).

<sup>112</sup> *See id.* at 553–54.

<sup>113</sup> *Id.* at 557–58.

decisions, whether that be the pursuit of nuclear energy or the research of solar geoengineering.

There are also administrative hurdles to contend with. Through guidance, NOAA has established CXs that could readily be applied to the stratospheric research program mandated by Congress.<sup>114</sup> Agencies develop CXs for application to frequent agency actions that do not merit environmental review because they have no or low impact on the physical environment. Applying a CX obviates the need to do further NEPA analysis in the form of an EA or EIS. A CX is available for NOAA computer modeling, data analysis, and project development for research activities.<sup>115</sup> Another CX would cover in-person or electronic remote observation of natural phenomena, such as atmospheric data collection from weather balloons.<sup>116</sup> A third CX could be applied to “invasive [research] techniques,” so long as they comply with federal environmental protection laws, occur on a small scale, and have “no long-term adverse ecosystem impacts.”<sup>117</sup> The examples given for this third CX imply it is geared toward minimally invasive research of living resources, like fish tagging and small-scale sampling.<sup>118</sup> Its language, however, would cover the negligible atmospheric aerosol release of an experiment like SCoPEX, representing the outer bound of the potential impact of near-term research.<sup>119</sup>

### *B. Opportunities for NEPA Review*

The legal structure described above outlines the circumstances that compel NEPA review and the minimum requirements of that analysis. Federal agencies, however, may go beyond NEPA’s statutory minimum, especially in light of extraordinary or highly controversial proposals. Solar geoengineering research calls for just that.

The same NOAA guidance that establishes CXs under NEPA counsels that more in-depth analysis may be warranted in “extraordinary circumstances,” such as activities with “highly controversial environmental effects.”<sup>120</sup> CEQ implementing regulations for NEPA recognize a similar exception: “An agency may . . . prepare environmental assessments” for

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<sup>114</sup> See NAT’L OCEANIC & ATMOSPHERIC ADMIN. & U.S. DEP’T OF COM., POLICY AND PROCEDURES FOR COMPLIANCE WITH THE NATIONAL ENVIRONMENTAL POLICY ACT AND RELATED AUTHORITIES app. E at E-7–E-9, reference nos. E1, E3, E5 (2017) [hereinafter NOAA & U.S. DEP’T OF COM.].

<sup>115</sup> See *id.* app. E at E-7–E-8, reference no. E1.

<sup>116</sup> See *id.* app. E at E-8–E-9, reference no. E3.

<sup>117</sup> See *id.* app. E at E-9, reference no. E5.

<sup>118</sup> See *id.* app. E at E-9–E-10, reference no. E5.

<sup>119</sup> SCoPEX is used for analytic purposes. NOAA Research has announced no similar outdoor experiments in connection to this program.

<sup>120</sup> *Id.* at 4–5.

some actions otherwise eligible for CXs in light of “extraordinary circumstances.”<sup>121</sup> The word *may* is permissive; the agency is under no obligation to do an EA where a CX is sufficient.<sup>122</sup> But agencies retain the authority to conduct a more expansive environmental review where they believe it prudent.<sup>123</sup> Congress’s instruction to assess climate interventions is certainly extraordinary: the program is unusual, contrary to prevailing environmental norms, and essentially unprecedented among national governments.<sup>124</sup> Solar geoengineering research is also extremely controversial, despite the minimal impacts that planned and foreseeable research activities would have for the physical environment.<sup>125</sup> It would therefore be within NOAA’s discretion to launch a PEA on the first federal research program into solar climate interventions.<sup>126</sup>

The PEA could consider the relationship between federally controlled research, federally funded research, and purely private research subject to federal permitting, such as SCoPEX and its peers. Specific research activities covered could include modeling, atmospheric observations, and minimally intrusive field experiments to collect data or aid in technology design. The

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<sup>121</sup> See 40 C.F.R. § 1508.4 (2010), *rescinded and replaced by* Update to the Regulations Implementing the Procedural Provisions of the National Environmental Policy Act, 85 Fed. Reg. 43,304 (July 16, 2020). CEQ’s recently finalized replacement regulations similarly allow agencies to conduct EAs where a CX is available in light of extraordinary circumstances. See Update to the Regulations Implementing the Procedural Provisions of the National Environmental Policy Act, 85 Fed. Reg. at 43,322–23 (to be codified at 40 C.F.R. § 1501.4).

<sup>122</sup> See *id.* at 43,322–23.

<sup>123</sup> Courts tend to narrowly interpret NEPA’s “controversy” factor as requiring scientific uncertainty or disagreement over a proposal’s physical impacts rather than political opposition or social unrest regarding a proposal. See Emily M. Slaten, Note, “*We Don’t Fish in Their Oil Wells, and They Shouldn’t Drill in Our Rivers*”: *Considering Public Opposition Under NEPA and the Highly Controversial Regulatory Factor*, 43 IND. L. REV. 1319, 1328–29 (2010); see also William Murray Tabb, *The Role of Controversy in NEPA: Reconciling Public Veto with Public Participation in Environmental Decisionmaking*, 21 WM. & MARY ENV’T L. & POL’Y REV. 175, 188–90 (1997) (arguing courts are inconsistent vis-à-vis “controversy” but tend to defer to agency determinations on that point).

<sup>124</sup> See Extraordinary, 5 OXFORD ENGLISH DICTIONARY 614 (2d ed. 1989).

<sup>125</sup> See Carola Braun, Christine Merk, Gert Pönitzsch, Katrin Rehdanz & Ulrich Schmidt, *Public Perception of Climate Engineering and Carbon Capture and Storage in Germany: Survey Evidence*, 18 CLIMATE POL’Y 471, 473, 475 (2017); Malcolm J. Wright, Damon A. H. Teagle & Pamela M. Feetham, *A Quantitative Evaluation of the Public Response to Climate Engineering*, 4 NATURE CLIMATE CHANGE 106, 107 tbl.1, 109 fig.2 (2014).

<sup>126</sup> See Update to the Regulations Implementing the Procedural Provisions of the National Environmental Policy Act, 85 Fed. Reg. 43,364 (to be codified at 40 C.F.R. § 1502.4); NOAA & DEP’T OF COM., *supra* note 114, at 8. Separate CEQ guidance advises programmatic review can take the form of either an EA or EIS. See Memorandum from Michael Boots, *supra* note 29, at 12. The Boots memo interprets the now-repealed NEPA implementing regulations, but CEQ finalized essentially the same language in the corresponding section of the replacement rules. Compare 40 C.F.R. § 1501.4 (repealed on September 13, 2020), with 85 Fed. Reg. 43,364 (to be codified at 40 C.F.R. § 1502.4) (current regulations).

PEA, however, should exclude activities with a lasting, large, or widespread effect on climate or otherwise resulting in significant physical impacts.<sup>127</sup> Research with greater impacts would trigger a more intensive environmental review, and they are well beyond the scope of likely near-term research programs.<sup>128</sup> Once complete, the PEA could then be incorporated by reference when NOAA Research applies CXs to individual experiments and research projects. Other research agencies or agencies involved in the permitting of private solar geoengineering research, such as the FAA, could also rely on the PEA when invoking their own CXs.

NOAA seems a good fit to lead this review—in consultation with the FAA, EPA, and other agencies—given its duties to research earth systems, protect marine environments, and manage living resources. Some lawmakers agree on this point. A bill introduced in the U.S. House would expand NOAA’s formal authority to receive reports and give recommendations on solar geoengineering field research, though it would still lack permitting authority over such activities.<sup>129</sup> There would also be precedent within NOAA for such a PEA. NOAA has completed PEAs for marine turtle research and coastal hydrographic survey programs, though they lacked significant direct impacts on the physical environment.<sup>130</sup> What the agency has done before, it can do again.

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<sup>127</sup> Cf. Michael Burger & Justin Gundlach, *Research Governance*, in CLIMATE ENGINEERING AND THE LAW 269, 294 fig.6.1 (Michael B. Gerrard & Tracy Hester eds., 2018) (grouping solar geoengineering research activities into phases based on scale and purpose).

<sup>128</sup> See *id.*

<sup>129</sup> See Atmospheric Climate Intervention Research Act, H.R. 5519, 116th Cong. § 3 (2019) (proposing to amend NOAA Research’s organic statute, 33 U.S.C. § 893, to expressly cover solar geoengineering research activities and to clarify the agency’s advisory role on private sector weather modification activities under the Weather Modification Reporting Act of 1972). The Weather Modification Reporting Act requires any private person to submit a report to the Secretary of Commerce on “any weather modification activity,” see 15 U.S.C. § 330a, defined as “any activity performed with the intention of producing artificial changes in the composition, behavior, or dynamics of the atmosphere.” 15 U.S.C. § 330. The Secretary later delegated this responsibility to NOAA Research. NOAA’s implementing regulations clarify that this reporting requirement applies to solar geoengineering activities. See 15 C.F.R. § 908.3(a)(3) (“[W]eather modification activities . . . subject to reporting [include] . . . “[m]odifying the solar radiation exchange of the earth or clouds, through the release of gases, dusts, liquids, or aerosols into the atmosphere.”). NOAA may notify local authorities or issue recommendations in response to such reporting, but “[n]otification or recommendation, or failure to notify or recommend, shall not be construed as approval or disapproval of a proposed project.” 15 C.F.R. § 908.12(d) (emphasis added); see also *id.* (describing the agency’s order as “advisory”). H.R. 5519 thus would formally recognize NOAA Research’s advisory role in private solar geoengineering research proposals but would not give it authority to regulate by permit.

<sup>130</sup> See NAT’L OCEANIC & ATMOSPHERIC ADMIN., NAT’L MARINE FISHERIES SERV. & PAC. ISLANDS FISHERIES SCI. CTR., PROGRAMMATIC ENVIRONMENTAL ASSESSMENT OF THE MARINE TURTLE RESEARCH PROGRAM (MTRP) AT THE PACIFIC ISLAND FISHERIES SCIENCE CENTER (PIFSC), PROTECTED SPECIES DIVISION (PSD) 2 (2011) [hereinafter NAT’L OCEANIC & ATMOSPHERIC ADMIN.]; OFF. OF

The PEA process could begin by publishing a request for public comment for scoping the proposed research and the concerns that environmental review should address.<sup>131</sup> This would allow for experts and the interested public to weigh in on the agency's initial research plan. Once scoping is complete, the agency could evaluate the risks associated with different research plans and potential methods to limit those risks. To address slippery slope concerns, for example, NOAA Research could articulate limits to the research objectives and activities. The PEA could also give some consideration to the more abstract risks associated with an early research program, such as moral hazard. It may also consider the more abstract risks of *not* doing research, namely, a warmer world facing mounting climate harms but lacking experience with SAI research and governance.

The NEPA process would also be an opportunity to engage with the public. It would provide for public comment and public hearings, with remarks noted and responded to within the PEA.<sup>132</sup> The NEPA process would give NOAA Research a chance to contextualize the program, describe its negligible physical impacts, and correct possible misconceptions about solar geoengineering.<sup>133</sup> Finally, NOAA Research could give assurances that research will not slip into SAI technology development or deployment—perhaps by making such promises in the Record of Decision produced at the close of the NEPA process. Such commitments would be binding: courts can enforce mitigation and control measures announced in the Records of Decision.<sup>134</sup> NEPA, of course, does not compel any mitigation or control measures. The agency would decide how much responsibility to take on. But the option is available to make binding commitments to the public if the agency wishes to do so.

#### IV. WHY GOVERN?

This expansive approach to NEPA may strike some as counterintuitive. NEPA can be a burdensome exercise in low-quality information

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COAST SURVEY, NAT'L OCEANIC & ATMOSPHERIC ADMIN., PROGRAMMATIC ENVIRONMENTAL ASSESSMENT FOR THE OFFICE OF COAST SURVEY HYDROGRAPHIC SURVEY PROJECTS 8–9 (2013).

<sup>131</sup> Scoping is the process of identifying and defining issues requiring environmental analysis. See 40 C.F.R. § 1501.9 (effective Sept. 14, 2020).

<sup>132</sup> See *Weinberger v. Cath. Action of Haw.*, 454 U.S. 139, 143 (1981) (“Through the disclosure of an EIS, the public is made aware that the agency has taken environmental considerations into account.”).

<sup>133</sup> See Charles R. Corbett, *Chemtrails and Solar Geoengineers: Governing Online Conspiracy Theory Misinformation*, 85 MO. L. REV. (forthcoming 2021) (manuscript at 13) (on file with author) (describing pervasive misinformation online about solar geoengineering); see also Dustin Tingley & Gernot Wagner, *Solar Geoengineering and the Chemtrails Conspiracy on Social Media*, 3 PALGRAVE COMM'NS 1, 1–2 (2017).

<sup>134</sup> See Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations, 46 Fed. Reg. 18,026, 18,037 (Mar. 23, 1981).

production.<sup>135</sup> Its laboriousness incentivizes agencies to minimize or downplay environmental impacts to avoid triggering in-depth environmental assessments.<sup>136</sup> Judicial review can also greatly add to the agency's administrative burden; NEPA processes frequently give rise to environmental litigation against agency decision-making.<sup>137</sup> Given these considerations, agency officials may wonder why an agency would ever volunteer for a more comprehensive NEPA review.

There are three reasons why. First, NEPA's public participation components and procedural rigor would bolster the project's legitimacy. Second, it may improve the research agenda and governance, while also giving complimentary climate policy processes time to come to fruition. Third, it would serve as a valuable opportunity for the agency to provide global leadership on solar geoengineering governance at a relatively low administrative cost.

#### A. Legitimacy

*Legitimacy* describes a valid or rightful use of power by a governing authority.<sup>138</sup> Roughly speaking, a government action can be found legitimate where it is lawful, justified, and socially accepted.<sup>139</sup> Within liberal democracies, legitimacy often “invokes . . . values including responsiveness, transparency, participation, deliberation[,] and [public] engagement.”<sup>140</sup> Such societies often enact those democratic values by incorporating robust public participation mechanisms in government decision-making.<sup>141</sup> It follows that robust public participation mechanisms can also bolster the legitimacy of federal solar geoengineering research.<sup>142</sup> Of course, there are other sources of legitimacy—the administrative state, in particular, can claim

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<sup>135</sup> See Karkkainen, *supra* note 93, at 917.

<sup>136</sup> See *id.* at 936; COUNCIL ON ENV'T QUALITY, EXEC. OFF. OF THE PRESIDENT, FACT SHEET: CEQ'S PROPOSAL TO MODERNIZE ITS NEPA IMPLEMENTING REGULATIONS 1 (2020).

<sup>137</sup> See, e.g., AUDREY BIXLER, R. PATRICK BIXLER, AUTUMN ELLISON & CASSANDRA MOSELEY, ADMINISTRATIVE AND JUDICIAL REVIEW OF NEPA DECISIONS: RISK FACTORS AND RISK MINIMIZING STRATEGIES FOR THE FOREST SERVICE 16–19 (2016) (reviewing literature describing NEPA cases brought against the U.S. Forest Service).

<sup>138</sup> See Arthur Isak Applbaum, *Legitimacy Without the Duty to Obey*, 38 PHIL. & PUB. AFFS. 215, 216–17 (2010) (arguing legitimacy at minimum encompasses “the right to rule”).

<sup>139</sup> See Steven Bernstein, *Legitimacy in Intergovernmental and Non-State Global Governance*, 18 REV. INT'L POL. ECON. 17, 20–21, 42 (2011).

<sup>140</sup> *Id.* at 22.

<sup>141</sup> See *id.* But see Jim Rossi, *Participation Run Amok: The Costs of Mass Participation for Deliberative Agency Decisionmaking*, 92 NW. U. L. REV. 173, 174 (1997) (describing this attitude toward public participation in administrative law as a “fetish”).

<sup>142</sup> See Jane A. Flegal, Anna-Maria Hubert, David R. Morrow & Juan B. Moreno-Cruz, *Solar Geoengineering: Social Science, Legal, Ethical, and Economic Frameworks*, 44 ANN. REV. ENV'T & RES. 399, 404–06 (2019).

the right to govern via reasonable, lawful expert decision-making.<sup>143</sup> But a claim to legitimacy can be derived from multiple sources at once.<sup>144</sup> With an endeavor as controversial and troubling as solar geoengineering, NOAA and the federal government would do well to make as strong a case as they can.<sup>145</sup>

The NEPA process would allow NOAA meaningful public engagement in research activities. At a basic level, the public engagement process is a chance for agencies to inform and educate people on projects that may affect them.<sup>146</sup> These members of the public are *stakeholders* as they “have an interest or stake in an issue, such as individuals, interest groups, [or] communities.”<sup>147</sup> Once informed, the public can then weigh in on the proposal, potentially influencing the agency’s decision-making.<sup>148</sup>

Of course, public engagement does not necessarily mean public control. An agency can scale the level of public participation depending on a project’s potential impacts and the discretion it has over implementation.<sup>149</sup> Lower risk and fewer discretion cuts in favor of less public inclusion. Greater risk and more open-ended program needs, however, could be reasons for greater collaboration with stakeholders. At the low end of public engagement, the agency could limit itself to merely informing the public of the nature of the project without giving members of the public an opportunity to comment.<sup>150</sup> At the high end, the agency could delegate final decision-making authority to the public by ballot or proxy vote.<sup>151</sup>

The amount of public engagement needed for initial federal research of solar geoengineering lies somewhere between these extremes. Specifically, NOAA should engage in a consultation process with the interested public that informs them of the nature and bounds of its stratospheric aerosol

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<sup>143</sup> See Lisa Schultz Bressman, *Beyond Accountability: Arbitrariness and Legitimacy in the Administrative State*, 78 N.Y.U. L. REV. 461, 470–72, 553–56 (2003).

<sup>144</sup> See Bernstein, *supra* note 139, at 23, 42.

<sup>145</sup> See SHUCHI TALATI & PETER C. FRUMHOFF, STRENGTHENING PUBLIC INPUT ON SOLAR GEOENGINEERING RESEARCH 3–4 (2020); see also Michael B. Gerrard, *Introduction*, in CLIMATE ENGINEERING AND THE LAW 1, 25–26 (Michael B. Gerrard & Tracy Hester eds., 2018) (outlining a governance structure that could bolster legitimacy of research).

<sup>146</sup> See Adrien Abecassis, Charles R. Corbett, Benjamin Harris, Edward A. Parson & Jesse L. Reynolds, Comment on the Proposed Governance Framework for Harvard University’s Stratospheric Controlled Perturbation Experiment (“SCoPEX”) by the SCoPEX Advisory Committee. 2 (July 31, 2020), <https://legal-planet.org/wp-content/uploads/2020/08/SCoPEX-comment-letter-31Jul2020-Submitted.pdf> [<https://perma.cc/68F5-6NQB>] [hereinafter Comment Letter].

<sup>147</sup> EPA, INTRODUCTION TO THE PUBLIC PARTICIPATION TOOLKIT 3, [https://www.epa.gov/sites/production/files/2014-05/documents/ppg\\_english\\_full-2.pdf](https://www.epa.gov/sites/production/files/2014-05/documents/ppg_english_full-2.pdf) [<https://perma.cc/5VYB-PHDM>].

<sup>148</sup> Comment Letter, *supra* note 146, at 2.

<sup>149</sup> EPA, *supra* note 147, at 12–16.

<sup>150</sup> *Id.* at 14.

<sup>151</sup> *Id.* at 15.



research, invites comment, reviews, faithfully deliberates on the issues raised, and meaningfully responds.<sup>152</sup> A meaningful response could include revising the program's design or controls, depending on the agency's resources, objectives, and flexibility. Critically, it would also give NOAA an opportunity to inform the public on what the research is *not*. A significant portion of public discourse on solar geoengineering is distorted by conspiracy theory misinformation.<sup>153</sup> A public engagement process with a robust education component could inoculate some members of the public against misinformation on the subject.<sup>154</sup>

The NEPA process is well equipped to facilitate such a public consultation—perhaps uniquely so. NEPA requires agencies to publicly share information and analysis on environmentally significant proposals. It creates an opportunity for public comment, and the agency is obliged to review, summarize, and respond to those comments. Though agencies need not act on the issues raised, NEPA provides opportunity and incentive to correct course, thus making project improvement more likely. Finally, the process is subject to a well-developed body of case law and an expansive set of implementing regulations.<sup>155</sup> These legal authorities would give the environmental review process the concreteness and heft that a completely voluntary, nonstatutory public engagement process would lack. An environmental assessment under the auspices of federal law simply has a stronger claim to legitimacy than one occurring via an informal, ad hoc, or completely voluntary process.<sup>156</sup>

Another element of legitimacy is lawfulness: a legitimate agency action complies with the requirements of the law in good faith.<sup>157</sup> Here, full and faithful satisfaction of NEPA militates in favor of providing at least some risk analysis. Congress's appropriation to NOAA Research is genuinely extraordinary, and NEPA urges agencies to thoughtfully consider *ex ante* the potential environmental consequences of extraordinary or controversial proposals. Moreover, the potential risks at hand with solar geoengineering

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<sup>152</sup> See Comment Letter, *supra* note 146, at 6–7 (citing EPA, *supra* note 147, at 14).

<sup>153</sup> See Corbett, *supra* note 133, at 13.

<sup>154</sup> See *id.* at 9.

<sup>155</sup> See Spensley, *supra* note 74, at 682–90.

<sup>156</sup> Nonstate governance processes can still make a strong claim to legitimacy on the basis of “effectiveness, efficiency, expertise, and open, fair procedures.” Jesse L. Reynolds & Edward A. Parson, *Nonstate Governance of Solar Geoengineering Research*, 160 CLIMATIC CHANGE 323, 336 (2020). The argument here is that federal agencies have an independent claim to legitimacy by virtue of being a lawful part of the government. Moreover, agencies can simultaneously bolster their authority by demonstrating many of the same qualities and values that lend legitimacy to nonstate governance processes.

<sup>157</sup> See Bressman, *supra* note 143, at 556.

research are profoundly significant, if indirect and diffuse. Invoking a CX in these circumstances, and nothing more, would be inappropriate.

### *B. A Better Research Agenda*

More expansive NEPA review—one that goes beyond what the statute and the implementing regulations strictly require—may also improve the research agenda and its governance. There is a small but energetic community of scientific and governance experts working on issues raised by the prospect of solar geoengineering.<sup>158</sup> The agency should avail itself in a public comment period to the resources and expertise of these research communities, as NEPA would require. Doing so publicly via an open process would communicate and publicize the fact that this expert consultation is taking place, potentially bolstering public confidence in the program. Separately, it would allow experts to weigh in who were overlooked during informal agency consultation processes. Input from experts who have views contrary to stakeholders advocating for research would be particularly valuable. A public process can also improve the quality of input given by experts, as publication provides an incentive to sharpen, temper, and substantiate advice. Informal consultation processes, meanwhile, would remain available to elicit advice that experts may not wish to state publicly.

Comment from nonexperts and laypeople may also improve the quality of the research agenda.<sup>159</sup> The public, by virtue of its size and diversity, possesses knowledge and experiences the agency does not. Laypeople hence can provide new insights and identify weak points that government officials and experts may overlook. At a minimum, they can educate the agency on public preferences about the project.<sup>160</sup>

A public engagement period would also give a few complementary climate policy processes time to come to fruition. The National Academies of Sciences, Engineering and Medicine (NAS) is finalizing a report on research priorities and governance recommendations for solar geoengineering.<sup>161</sup> NAS recently produced an authoritative report on a research agenda on negative emissions technologies that has oriented

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<sup>158</sup> See IPCC, *supra* note 3, at 349–52 cross-ch. box 10 (summarizing findings of this scholarship).

<sup>159</sup> Rossi, *supra* note 141, at 182, 185–87 (explaining that public participation can “counteract[] myopia by improving information available to agency decisionmakers and citizens”).

<sup>160</sup> See *id.* at 186.

<sup>161</sup> See Talati, *supra* note 18; see also *Developing a Research Agenda and Research Governance Approaches for Climate Intervention Strategies That Reflect Sunlight to Cool Earth*, NAT’L ACADS. SCIS. ENG’G & MED., <https://www.nationalacademies.org/our-work/developing-a-research-agenda-and-research-governance-approaches-for-climate-intervention-strategies-that-reflect-sunlight-to-cool-earth> [<https://perma.cc/GB79-FRVF>].

research, development, and demonstration efforts in the field.<sup>162</sup> It is widely believed that NAS's report on solar geoengineering will prove similarly authoritative.<sup>163</sup> Investing time in a public engagement process would allow the Academy to complete its report. The agency could then incorporate NAS's findings into its final PEA and research plan.

Developing a PEA would also give the rest of the federal government time to commit to more vigorous climate mitigation and adaptation policies. President Biden has recently announced a suite of ambitious directives and initiatives on climate.<sup>164</sup> Solar geoengineering is no substitute for comprehensive climate policy. Proceeding with climate engineering research now, after President Trump withdrew from the Paris Agreement and repealed many climate regulations,<sup>165</sup> risks sending the dangerous message that SAI can replace or run ahead of deep emissions cuts. It would therefore be prudent to give the federal government time to begin realizing its climate strategy.<sup>166</sup> In this regard, NEPA's time investment would be another tool for improving the program's robustness.

### C. Model Governance at a Low Cost

Lastly, the final PEA and the public engagement process that created it would be valuable work products in themselves. The United States is breaking new ground with this research program. The final PEA could serve as a model governance document for other governments or institutions to consider when developing their own research priorities. For instance, the PEA could collect and digest resources on the environmental and social risks of solar geoengineering as well as the governance methods for limiting those risks. It could provide an opportunity for a clear, public articulation of the

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<sup>162</sup> See generally NAT'L ACADS. OF SCIS., ENG'G & MED., *NEGATIVE EMISSIONS TECHNOLOGIES AND RELIABLE SEQUESTRATION: A RESEARCH AGENDA* (2019) (surveying carbon dioxide removal technologies and identifying research needs).

<sup>163</sup> See, e.g., H. SELECT COMM. ON THE CLIMATE CRISIS, *supra* note 25, at 526 (recommending for Congress to "draw upon the findings of the forthcoming [NAS] study to establish a research program to investigate" solar geoengineering).

<sup>164</sup> *Fact Sheet: President Biden Takes Executive Actions to Tackle the Climate Crisis at Home and Abroad, Create Jobs, and Restore Scientific Integrity Across Federal Government*, WHITE HOUSE (Jan. 27, 2021) [hereinafter *Fact Sheet*] (outlining the new administration's plans on climate), <https://www.whitehouse.gov/briefing-room/statements-releases/2021/01/27/fact-sheet-president-biden-takes-executive-actions-to-tackle-the-climate-crisis-at-home-and-abroad-create-jobs-and-restore-scientific-integrity-across-federal-government/> [https://perma.cc/8P35-5XSN].

<sup>165</sup> See Quirin Schiermeier, *The US Has Left the Paris Climate Deal – What's Next?*, NATURE (Nov. 4, 2020), <https://doi.org/10.1038/d41586-020-03066-x> [https://perma.cc/VMN8-32GJ]; see also Nadja Popovich & Hiroko Tabuchi, *Tracking the Environmental Rules Reversed Under Trump*, N.Y. TIMES (May 13, 2020), <https://www.nytimes.com/2020/05/13/climate/nyt-climate-newsletter-trump-rollbacks.html> [https://perma.cc/Z5WX-KKAZ].

<sup>166</sup> See *Fact Sheet*, *supra* note 164.

program's purpose, which allows the agency to contextualize its research within overarching climate policy efforts. Private research entities and nonprofits are trying to launch similar public engagement processes,<sup>167</sup> but it is a job far better suited for the federal government. The administrative burden of the PEA would be small. NEPA can be unduly burdensome, but those critiques are raised in response to far more intensive environmental reviews analyzing significant physical impacts. It is highly unlikely that NOAA Research's PEA will uncover significant environmental impacts giving rise to the need for an extensive and expensive EIS. Similar PEAs that NOAA has completed were short by NEPA standards.<sup>168</sup> It is also unlikely that completing a PEA here would increase the agency's existing risk of litigation. Many stakeholders are deeply opposed to any solar geoengineering research.<sup>169</sup> NOAA Research faces risk of litigation regardless of how it decides to proceed under NEPA. Completing a PEA on its own initiative would communicate a good faith effort to comply with the statute's requirements.

#### CONCLUSION

Climate change affects everyone, and so does the prospect of solar geoengineering. The public deserves an opportunity to weigh in on the matter and be apprised of the significant environmental, social, and political risks of research. It is doubtful that these interests and concerns alone would be sufficient to compel environmental review under NEPA. Nonetheless, the federal government must take responsibility for its solar geoengineering research and govern it effectively. NOAA should not pass up this opportunity to demonstrate real leadership on climate policy.

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<sup>167</sup> See *About*, SCOPEX ADVISORY COMM., <https://scopexac.com/> [<https://perma.cc/448G-6ZXY>]; *What is C2G?*, C2G, <https://www.c2g2.net/what-is-c2g/> [<https://perma.cc/CXF4-FJAN>].

<sup>168</sup> See NAT'L OCEANIC & ATMOSPHERIC ADMIN., *supra* note 130.

<sup>169</sup> See, e.g., CTR. FOR INT'L ENV'T L., *FUEL TO THE FIRE: HOW GEOENGINEERING THREATENS TO ENTRENCH FOSSIL FUELS AND ACCELERATE THE CLIMATE CRISIS* 1–3 (2019); *Geoengineering: Unjust, Unproven and Risky*, FRIENDS OF THE EARTH, <https://foe.org/news/2015-02-geoengineering-unjust-unproven-and-risky/> [<https://perma.cc/9GPE-QFEV>]; KLEIN, *supra* note 12.